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(54) Pipe plugs

(57) A pipe plug (10) for sealing a pipe (12) at a selected location has a circumferential array of slips (18). In a first stage of securing the plug (10) in position, the slips (18) are moved relative to ramped faces (22) to engage against the interior of the pipe (12). In a second stage, the slips (18) are locked in that position by upstream pipeline pressure acting on a piston (30) to cause radial extension of plungers (26) via over-centre toggle links (40).

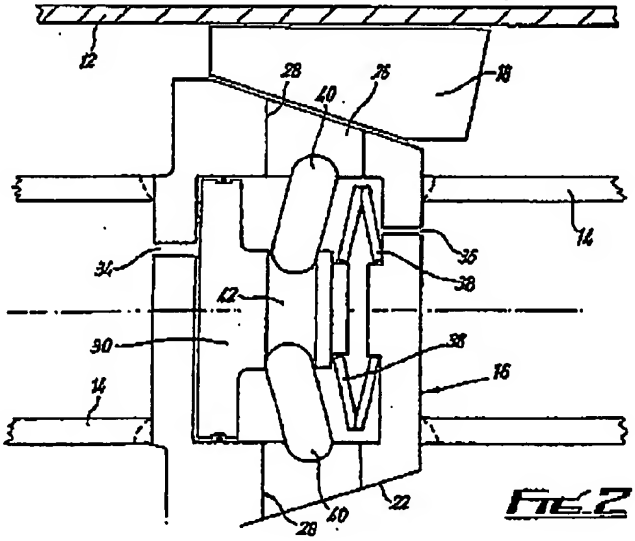

FIG.2

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

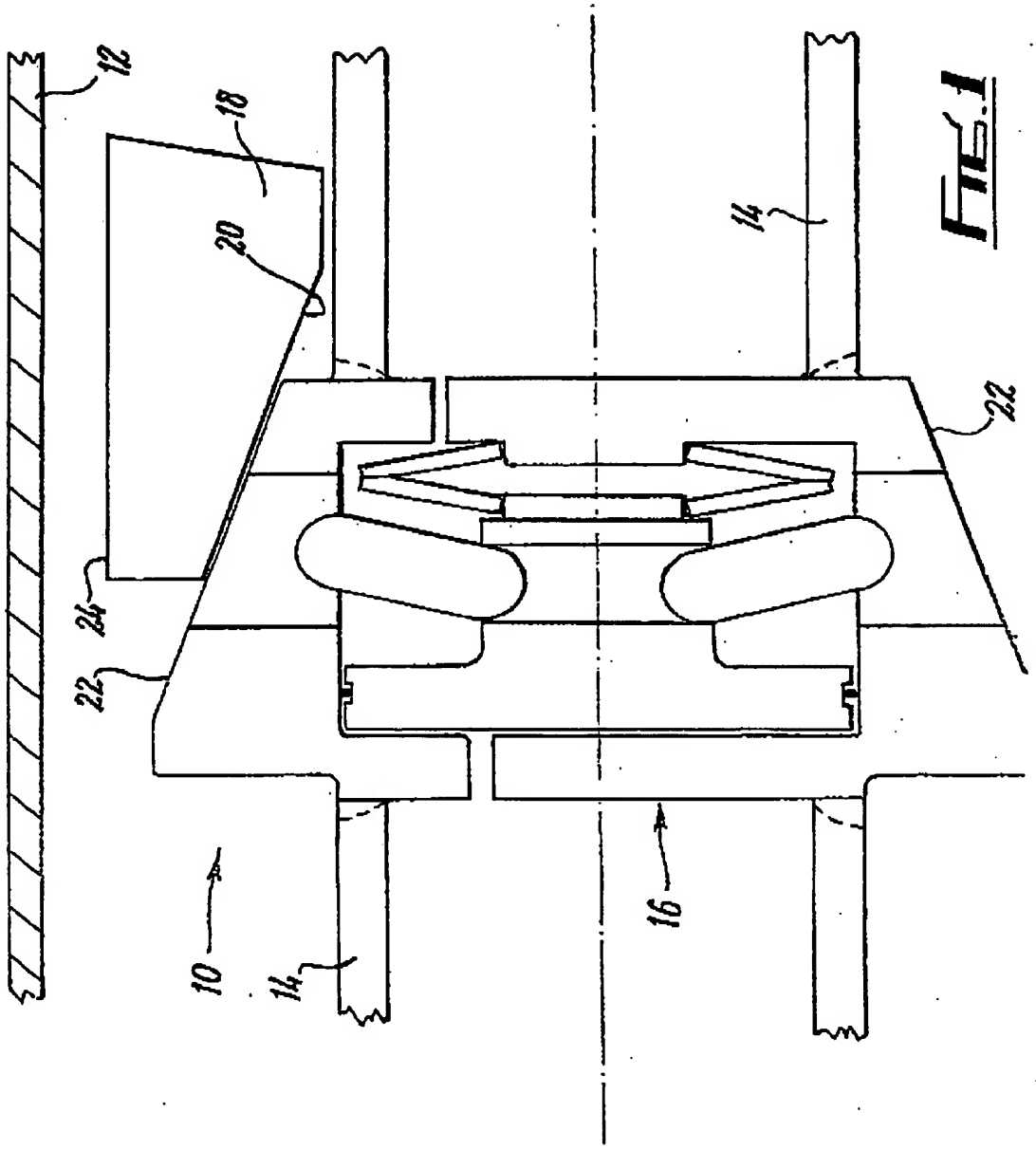

Fig.1

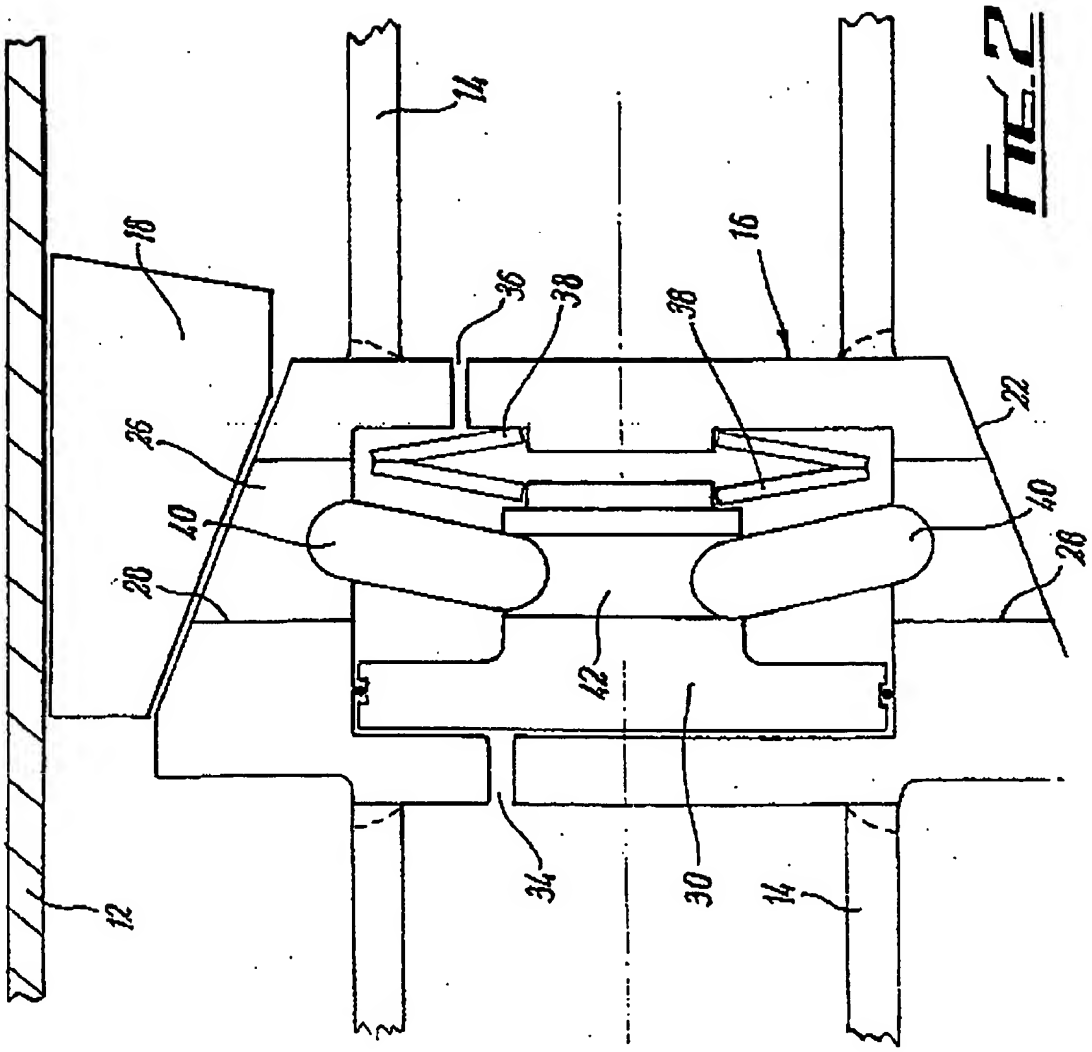

FIG. 2

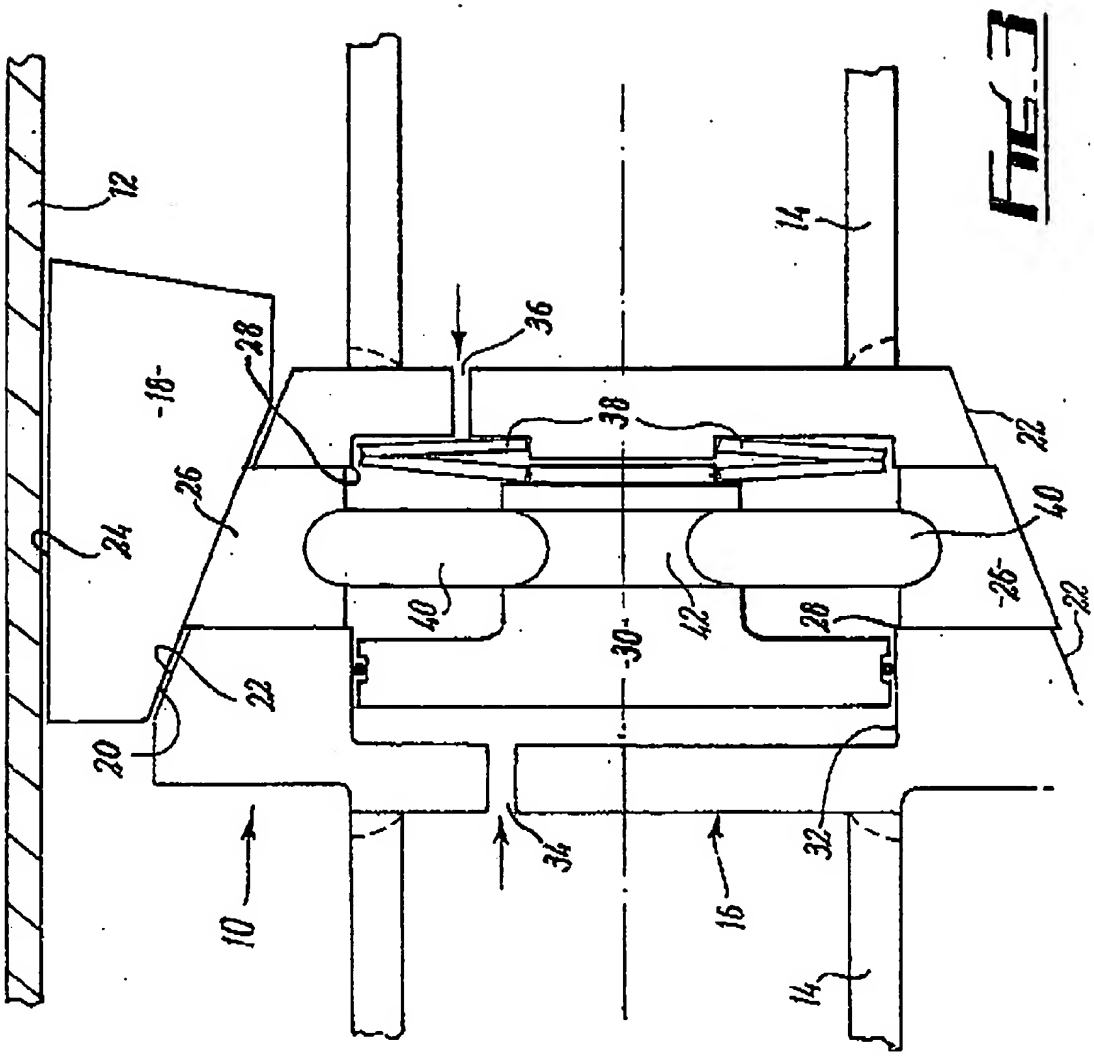

FIG. 3

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"PIPE PLUGS"

This invention relates to pipe plugs, and relates more particularly to pigs for temporarily plugging pipelines at selected locations.

It is well-known to employ pipelines to carry oil, gas or mixtures of these for substantial distances across land or sea. It may become necessary or desirable temporarily to block a pipeline at a location not fitted with a shut-off valve. In particular, if it is required to work on a short length of a long pipeline (eg to repair a leak or to fit a branch) at a location remote from either end of the pipeline, the choices are usually either to drain the entire pipeline or to isolate that short length such that only that short length requires to be drained. The latter course of action is preferable if the short length can be reliably isolated.

According to a first aspect of the present invention there is provided a pipe plug comprising a pig adapted to be transported along the bore of a pipeline and to be controllably anchored at a selected location along

said pipeline, said pig comprising anchor means engageable with the bore of the pipeline at said selected location in an initial stage of anchor operation, and locking means for locking the anchor means in engagement with the bore of the pipeline at said selected location in a subsequent stage of anchor operation.

The locking means preferably comprises over-centre toggle means disposed to act upon said anchor means after said initial stage of anchor operation to lock said anchor means in engagement with the pipeline bore by over-centring action whereby said anchor means are subsequently retained in a locked condition in engagement with the bore of the pipeline at least until a subsequent reversal of said over-centring action of said toggle means. Means to induce said over-centring action of said toggle means may comprise pressure sensitive means responsive to a difference in pressures at opposite ends of said pig. Said pressure sensitive means preferably comprises a piston means actuable by differential pressure across said piston means.

Said locking means may incorporate spring means biassing said over-centre toggle means away from a configuration in which said over-centring action occurs.

Said anchor means preferably comprises slip means and wedge means movable relative to said slip means to urge said slip means into engagement with the bore of said pipeline at said selected location as said initial stage of anchor operation.

Said slip means preferably comprises a plurality of

slips disposed around the periphery of the pig and arranged to be movable radially outwards of said pig by relative movement of said wedge means in a longitudinal direction. Said wedge means preferably comprises a like plurality of wedges longitudinally movable along respective paths radially inwards of an associated slip and radially outwards of said over-centre toggle means. Means to cause conjoint longitudinal movement of said wedges may comprise hydraulic piston means which preferably comprises a hydraulic piston longitudinally movable to act simultaneously on each said wedge.

Said pig preferably further comprises seal means for sealing said pig to the bore of said pipeline whereby substantially to prevent interchange of fluid between portions of said pipeline on either side of said pig.

According to a second aspect of the present invention there is provided a method of anchoring a pipe-plugging pig at a selected location along a pipeline, said method comprising the steps of providing a pipe-plugging pig according to the first aspect of the present invention, transporting said pig along the bore of the pipeline to said selected location, causing the anchor means of said pig to undergo an initial stage of anchor operation to engage the bore of the pipeline at said selected location, and subsequently mechanically locking said anchor means in engagement with the bore of the pipeline at said selected location.

According to a third aspect of the present invention there is provided a method of isolating a stretch of pipeline extending between a first selected location along said pipeline and a second selected location along said pipeline, said first and second selected

locations being mutually separated along said pipeline, said method comprising the steps of providing first and second pipe-plugging pigs each according to the first aspect of the present invention, transporting said first pig along the bore of the pipeline to said first selected location and there anchoring said first pig by the method according to the second aspect of the present invention, and transporting said second pig along the bore of the pipeline to said second selected location and there anchoring said second pig by the method according to the second aspect of the present invention.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings wherein:-

Figure 1 is a fragmentary longitudinal section of a pig in accordance with the present invention with pig anchors in a pre-anchored configuration;

Figure 2 is a view corresponding to Figure 1 but with the anchors at an initial stage of anchor operation;

Figure 3 is a view corresponding to Figure 2 but with the anchors at a subsequent stage of anchor operation.

Referring first to Fig. 1, part of a pig 10 is shown at a selected location within the bore of a pipeline 12 (only one side of which is shown). The pig 10 has a body 14 within which an anchor assembly 16 is mounted.

A circumferentially distributed array of slips 18 is located around the periphery of the anchor assembly 16, a suitable number of slips being eight for a pig having

a nominal outside diameter of 30 inches (762 millimetres). The slips 18 are allowed limited movements in longitudinal and radial directions by slip retainers which are omitted from the drawings for the sake of clarity. The slips 18 are biassed from the positions shown in Figs. 2 and 3 to the position shown in Fig. 1 by springs (not shown). The slips 18 have radially inner faces 20 which are radially tapered, and the periphery of the anchor assembly 16 is formed with matching tapered faces 22. Consequently, when the slips 18 are moved longitudinally to the left as viewed in Fig. 1, with respect to the remainder of the pig 10, by a hydraulic piston (not shown), the mutually engaging tapered faces 20 and 22 interact to move the slips radially outwards until their radially outer faces 24 engage the bore of the pipeline 12, as shown in Fig. 2 (to which reference will now be made). This initial operation of the anchor system of the pig 10 can be powered by any suitable on-board hydraulic power source, for example an accumulator (not shown) whose output is controlled by a suitable control valve (not shown) controlled in turn by any suitable control circuit (not shown).

Fig. 2 shows the anchor system of the pig 10 immediately after its initial stage of operation but before any subsequent stage of operation, ie the slips 18 have been moved to engage the bore of the pipeline 12 but the slips 18 have not yet been locked in their bore-engaging positions. Such locking of the slips 18 is brought about by a locking mechanism now to be described.

The locking mechanism comprises a plurality of plungers 26 each arranged to be radially slidable in a

respective radially extending bore 28 passing through a respective one of the tapered faces 22 on the periphery of the anchor assembly 16. In the non-locking configuration of the locking mechanism as shown in Fig. 2, the radially outer end of each of the plungers 26 is substantially flush with the respective tapered face 22 on the periphery of the anchor assembly 16.

Radial movement of the plungers 26 is caused by a longitudinally movable piston 30 slidingly sealed to the bore of a cylinder 32 coaxially formed in the centre of the anchor assembly 16 (itself coaxial with the pig 10). Pipeline pressure at either end of the pig 10 is conveyed to opposite faces of the piston 30 by respective hydraulic passages 34 and 36 such that the difference in fluid pressures between opposite ends of the pig 10 tends to move the piston 30 from the high-pressure end of the pig 10 towards the low-pressure end of the pig 10. The piston 30 is biassed leftwards as viewed in Fig. 2 by means of a back-to-back pair of dished annular springs 38 (Belleville springs) acting between the rightward end of the piston 30 (as viewed in Fig. 2) and the adjacent end wall of the cylinder 32.

Rightward longitudinal movement of the piston 30 induced by a left-to-right differential pressure (ie greater pressure in the passage 34 than in the passage 36) sufficient to overcome the leftward bias of the springs 38 is conveyed to each of the plungers 26 by a respective compression-resistant toggle strut 40 lodged at its radially inner hemispherical end in a circumferential concave groove 42 formed on the piston 30, and lodged at its radially outer hemispherical end in a matching concavity in the radially inner end of

the respective plunger 26. This locking movement is shown, at the moment of going over-centre, in Fig. 3 wherein the resultant radially outward movement of each of the plungers 26 forces each respective slip 18 into such tight engagement with the bore of the pipeline 12 as to ensure that the pig 10 can remain anchored against very high differential pressures, which may exceed 40 bar (ie the pig 10 is capable of self-anchoring against full pipeline pressure on its left end, with an empty vented pipeline at its right end).

Upon completion of the over-centering movement shown in Fig. 3, the toggle mechanism constituted by the plungers 26, the piston 30, and the struts 40 locks the anchor slips 18 in tight engagement with the bore of the pipeline 12 under minimal (or higher) differential pressure across the pig 10 without any dependence upon the on-board hydraulic supply utilised to produce the initial stage of operation of the anchor system (ie the transition from the Fig. 1 configuration to the Fig. 2 configuration). This ensures that anchorage of the pig 10 at the selected location in the pipeline 12 can continue even if the on-board hydraulic supply should fail, which is particularly important if the pipeline-plugging pig 10 is being utilised for the temporary isolation of a submarine oil pipeline downstream of the location selected for the pig to be anchored at, with the opening up of that downstream part of the pipeline; failure of this pig anchoring system would allow an uncontrolled release of the pipeline contents into the sea.

The radially outer end faces of the plungers 26 may be given high-friction surfaces to confer additional security to the anchoring function, by preventing

slippage of the tapered slip surfaces 20 under longitudinal loading. However, such high-friction surfaces would be expected to prevent free relative motion of the tapered surfaces 20 and 22 during unlocking and release of the anchor slips 18 were it not for the positive withdrawing action of the toggle mechanism as the piston 30 moves leftwards (as viewed in Figs. 1-3) to its inactive differential-pressure-free position, under the biassing influence of the springs 38.

Not shown in Figs. 1-3 are circumferentially extending peripheral seals at each end of the pig 10, the seals being a sliding fit on the bore of the pipeline 12 to seal the pig 10 to the pipeline bore. The pig 10 thus prevents any fluid flow between its opposite ends while being free to be driven along the pipeline 12 by differential fluid pressure between its opposite ends, until such time as the pig 10 is halted at a selected location along the pipeline and there anchored by the anchor system and anchoring procedure described above.

The apparatus and method described above allow the pipeline 12 to be temporarily blocked at a selected location, and hence enable the pipeline 12 to be isolated between that location and (for example) a stop valve (not shown) or some other pipeline isolation means. Greater operational flexibility may be achieved by duplicating the pipe-plugging arrangement depicted in Figs. 1-3, ie by providing a pair of pipe-plugging pigs as described with reference to Fig. 1, inserting and propelling both pigs down the pipeline, eventually halting the pigs at suitable respective locations for the isolation of a stretch of pipeline between these locations, and there anchoring each of the pigs at

their respective selected location by use of the anchor system and the anchoring procedures described above.

CLAIMS

1. A pipe plug comprising a pig adapted to be transported along the bore of a pipeline and to be controllably anchored at a selected location along said pipeline, said pig comprising anchor means engageable with the bore of the pipeline at said selected location in an initial stage of anchor operation, and locking means for locking the anchor means in engagement with the bore of the pipeline at said selected location in a subsequent stage of anchor operation.

2. A plug according to claim 1, in which the locking means comprises over-centre toggle means disposed to act upon said anchor means after said initial stage of anchor operation to lock said anchor means in engagement with the pipeline bore by over-centring action whereby said anchor means are subsequently retained in a locked condition in engagement with the bore of the pipeline at least until a subsequent reversal of said over-centring action of said toggle means.

3. A plug according to claim 2, including means to induce said over-centring action of said toggle means, comprising pressure sensitive means responsive to a difference in pressures at opposite ends of said pig.

4. A plug according to claim 3, in which said pressure sensitive means comprises a piston means actuable by differential pressure across said piston means.

5. A plug according to any of claims 2 to 4, in which said locking means incorporates spring means biassing

said over-centre toggle means away from a configuration in which said over-centring action occurs.

6. A plug according to any preceding claim, in which said anchor means comprises slip means and wedge means movable relative to said slip means to urge said slip means into engagement with the bore of said pipeline at said selected location as said initial stage of anchor operation.

7. A plug according to claim 6, in which said slip means comprises a plurality of slips disposed around the periphery of the pig and arranged to be movable radially outwards of said pig by relative movement of said wedge means in a longitudinal direction.

8. A plug according to claim 7, in which said wedge means comprises a like plurality of wedges longitudinally movable along respective paths radially inwards of an associated slip and radially outwards of said over-centre toggle means.

9. A plug according to claim 8, including means to cause conjoint longitudinal movement of said wedges, comprising hydraulic piston means.

10. A plug according to claim 9, in which the hydraulic piston means comprises a hydraulic piston longitudinally movable to act simultaneously on each said wedge.

11. A plug according to any preceding claim, further comprising seal means for sealing said pig to the bore of said pipeline whereby substantially to prevent interchange of fluid between portions of said pipeline

on either side of said pig.

12. A method of anchoring a pipe-plugging pig at a selected location along a pipeline, said method comprising the steps of providing a pipe-plugging pig according to claim 1, transporting said pig along the bore of the pipeline to said selected location, causing the anchor means of said pig to undergo an initial stage of anchor operation to engage the bore of the pipeline at said selected location, and subsequently mechanically locking said anchor means in engagement with the bore of the pipeline at said selected location.

13. A method of isolating a stretch of pipeline extending between a first selected location along said pipeline and a second selected location along said pipeline, said first and second selected locations being mutually separated along said pipeline, said method comprising the steps of providing first and second pipe-plugging pigs each according to claim 1, transporting said first pig along the bore of the pipeline to said first selected location and there anchoring said first pig by the method according to claim 12, and transporting said second pig along the bore of the pipeline to said second selected location and there anchoring said second pig by the method according to claim 12.